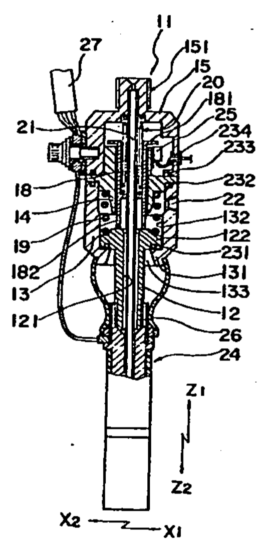
(12) UK Patent Application (19) GB (11) 2 118 524 A

(21) Application No 8309062
(22) Date of filing 31 Mar 1983
(30) Priority data
(31) 57/054109
(32) 31 Mar 1982
(33) Japan (JP)
(43) Application published
2 Nov 1983
(51) INT CL[3]
B25J 9/00
B23K 9/00 9/28
(52) Domestic classification
B8H 202 210 215 560 BA
B3R 31 32J 37A1A 37A1D
U1S 1592 1637 1673 B3R
B8H
(56) Documents cited
GB 2071608 A
GB 2068891 A
(58) Field of search
B8H
(71) Applicants
Osaka Transformer Co. Ltd.
(Japan),
1-11 Tagawa 2-chome,
Yodogawa-ku,
Osaka-shi,
Osaka-fu,
Japan
(72) Inventors
Toshiyuki Okada
Takafumi Uratani
(74) Agent and/or Address for Service
Boult, Wade and Tennant,
27 Furnival Street,
London EC4A 1PQ

(54) **Industrial robot**

(57) An industrial robot for use in a production line or the like, includes an operating member 24, for example a welding torch, supported so as to be free from positional deviations during operations of the robot and capable of being tilted and slidably moved with respect to a movable unit of the robot, so that the operating element is freely displaced in acting directions of external forces, without a possibility of damages to various parts and components, while any abnormal state in the above case may be detected by a single detector 25, irrespective of acting directions of external forces.

Fig. 4



GB 2 118 524 A

Fig. 1
PRIOR ART

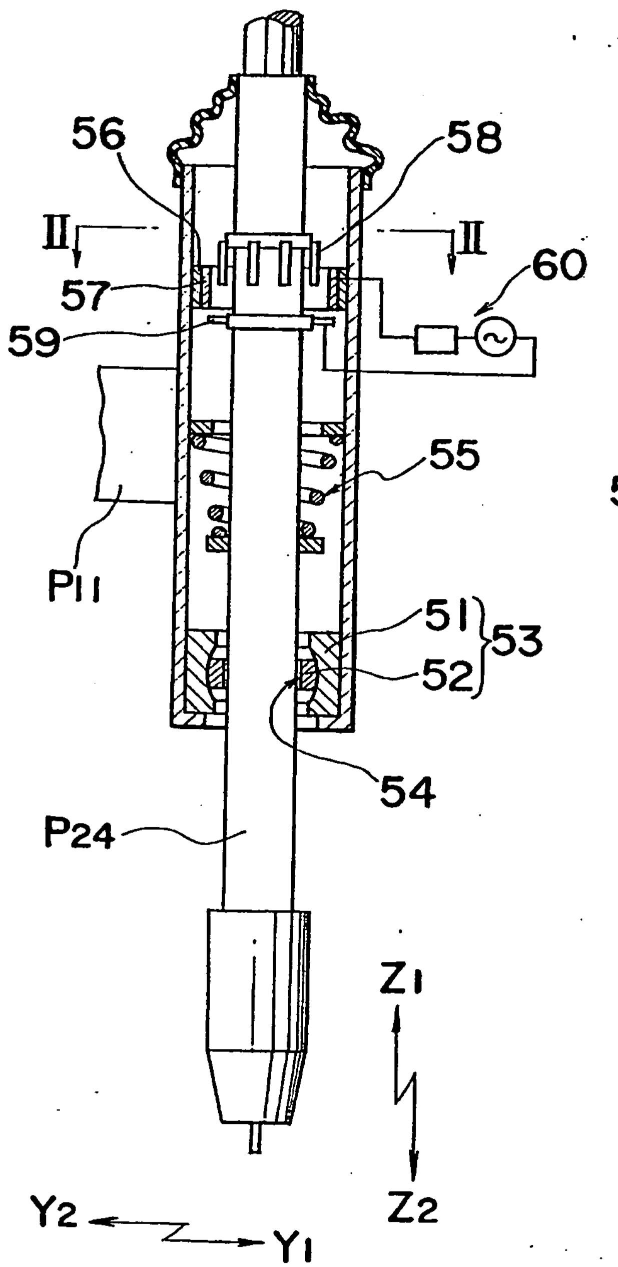


Fig. 2
PRIOR ART

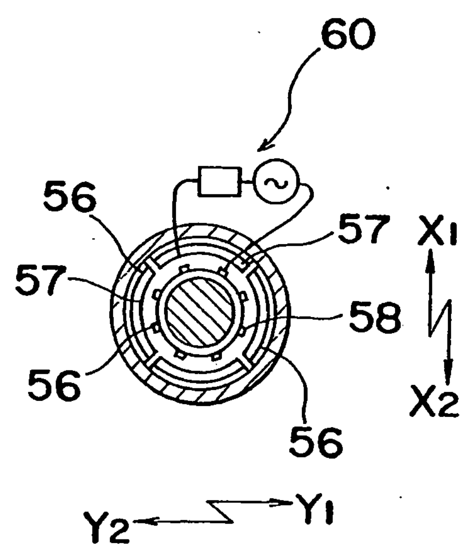


Fig. 3

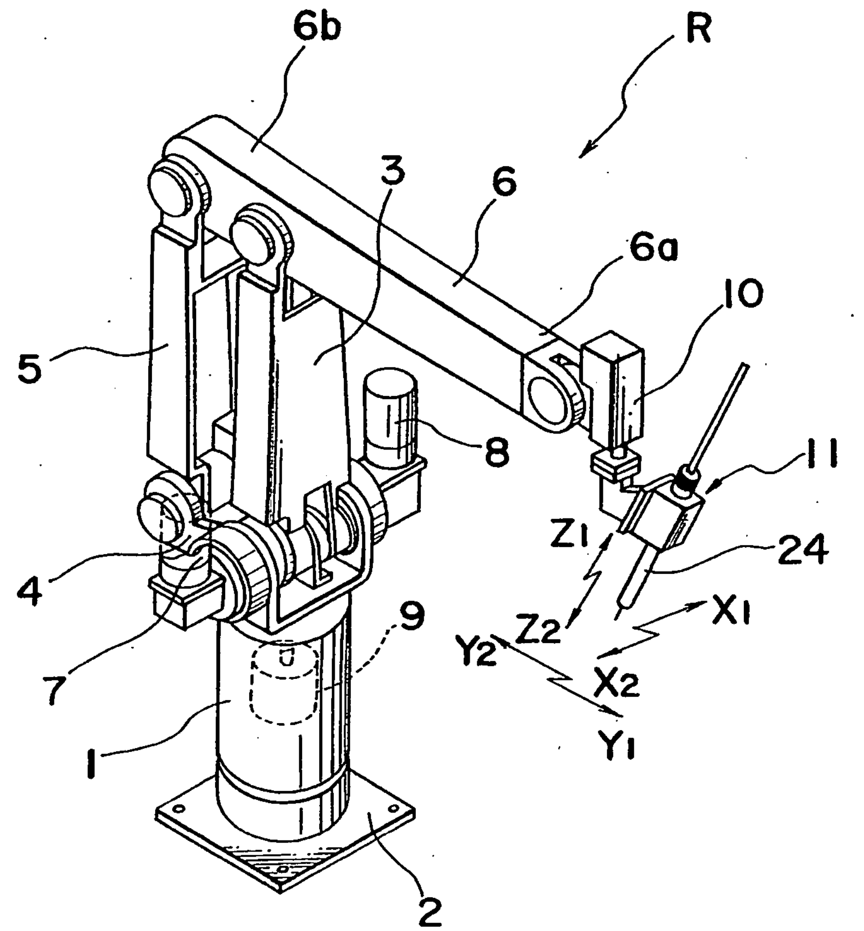


Fig. 4

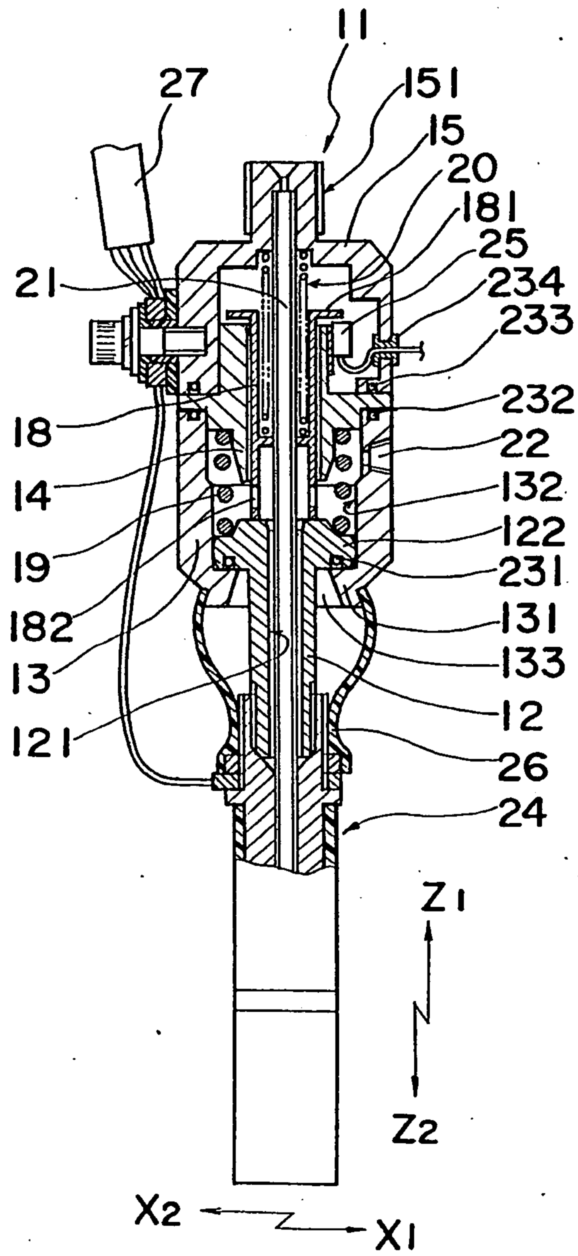

11
27
151
15
20
181
25
234
233
21
232
18
22
14
132
19
122
231
182
131
13
133
12
121
26
24
Z1
Z2
X2
X1

Fig. 5

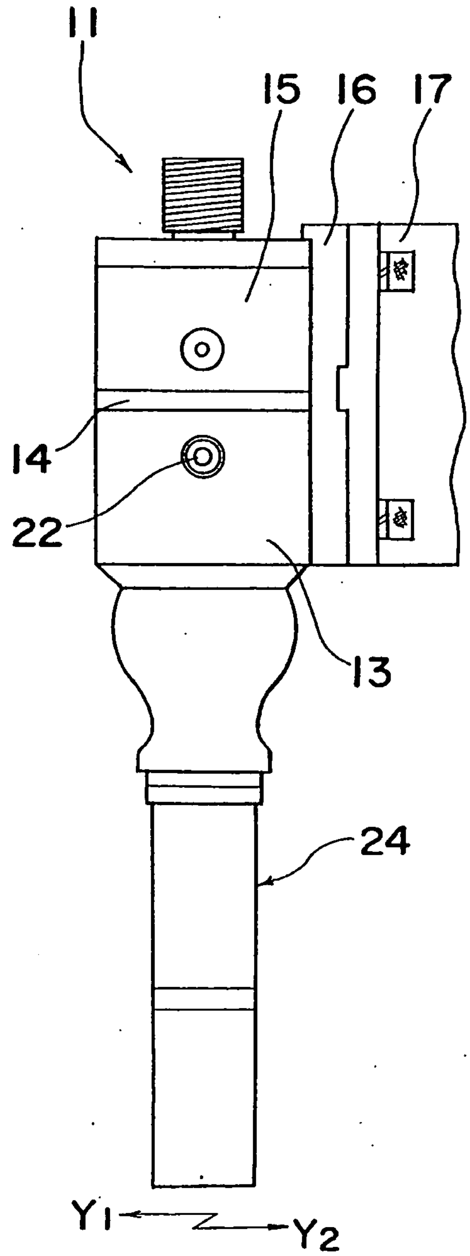

11
15
16
17
14
22
13
24
Y1
Y2

Fig. 6

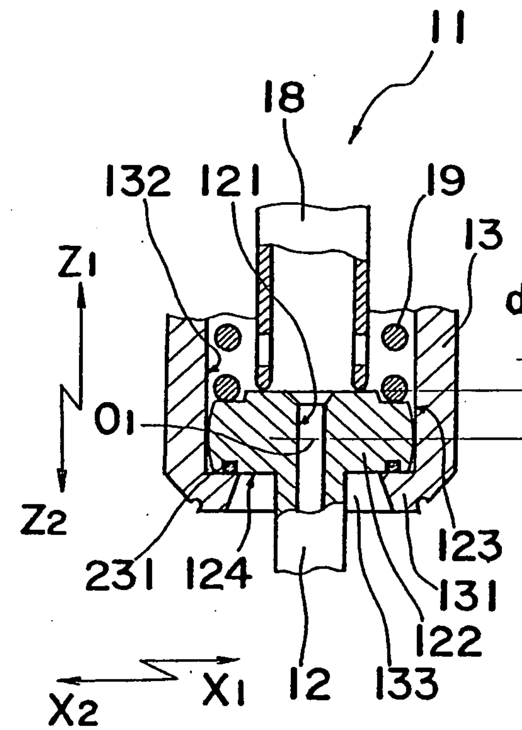


Fig. 7

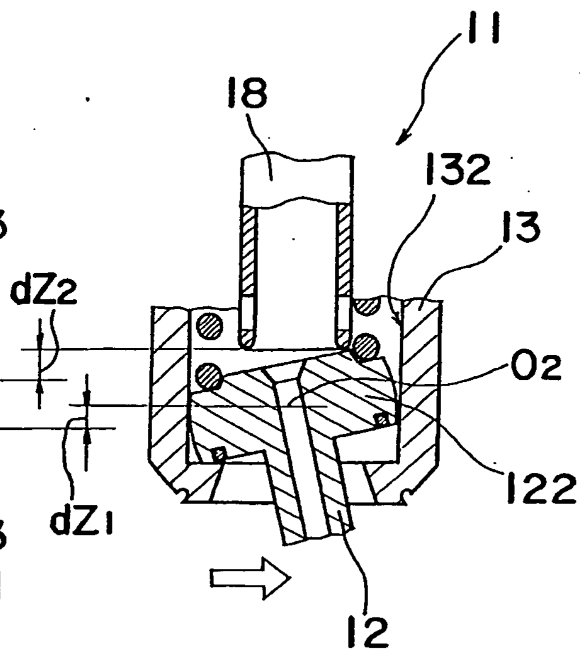


Fig. 8

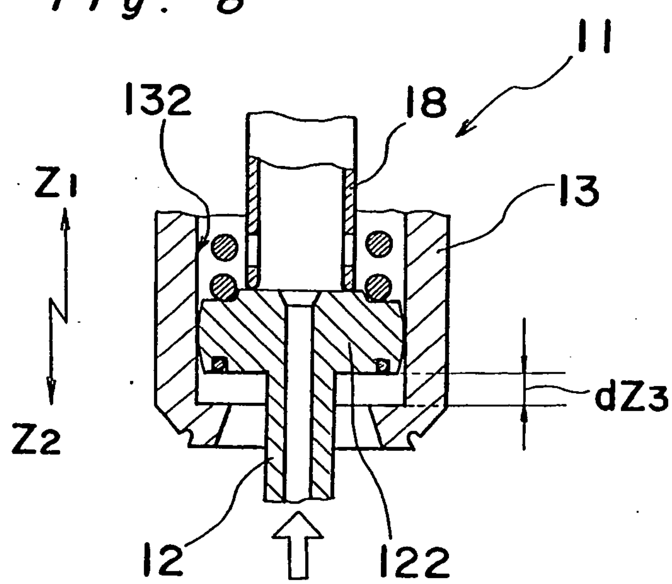


Fig. 9

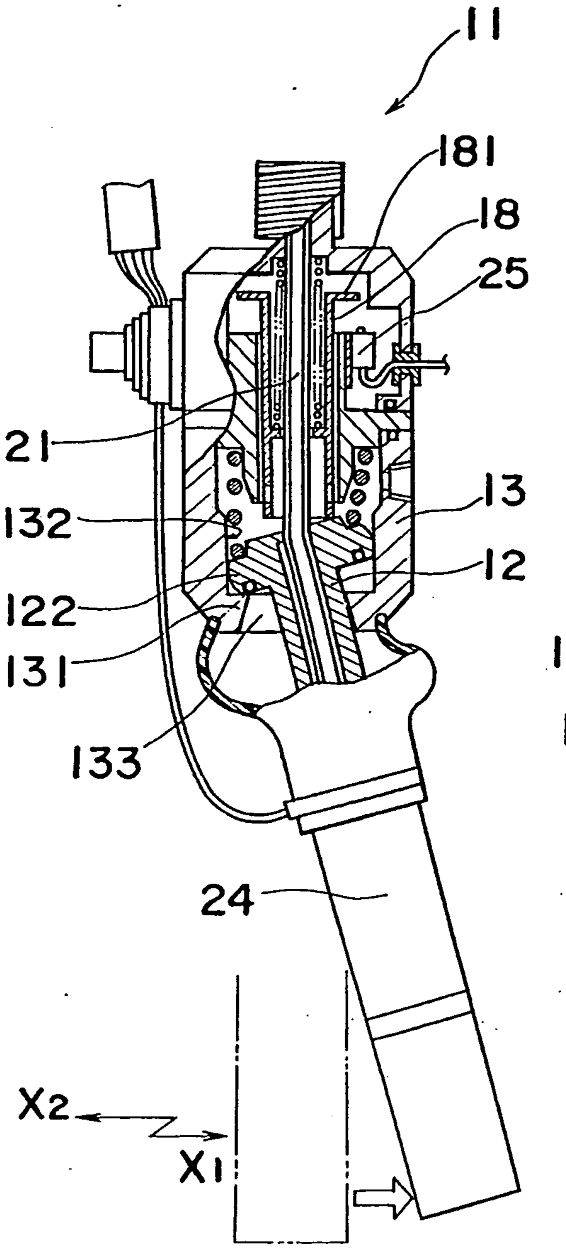

11
181
18
25
21
13
132
12
122
131
133
24
X2
X1

Fig. 10

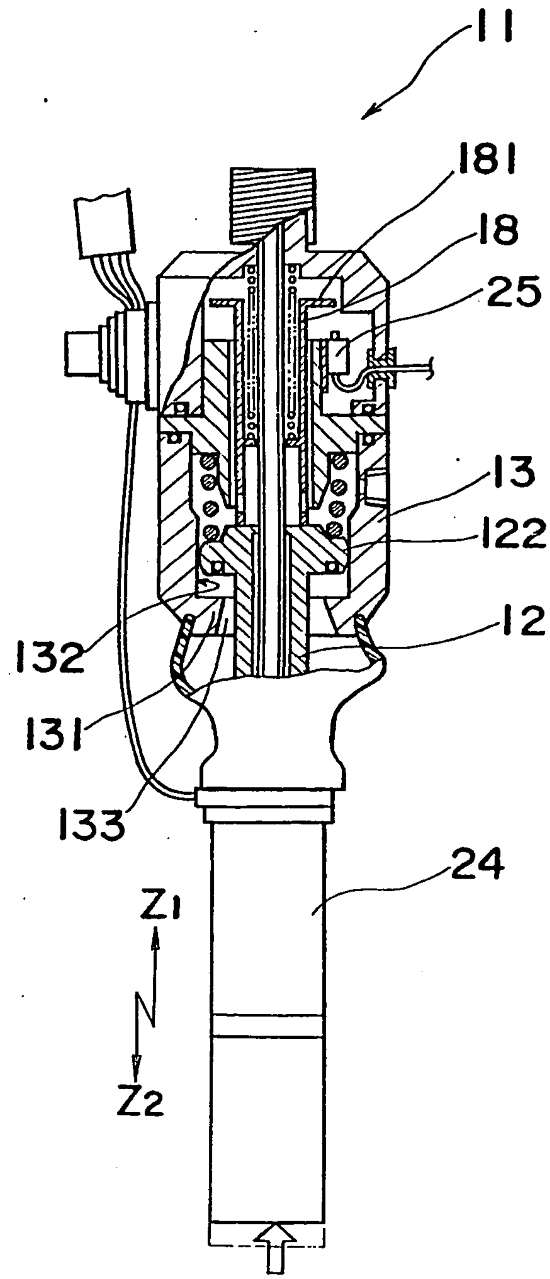

11
181
18
25
13
122
12
132
131
133
24
Z1
Z2

Fig. 11

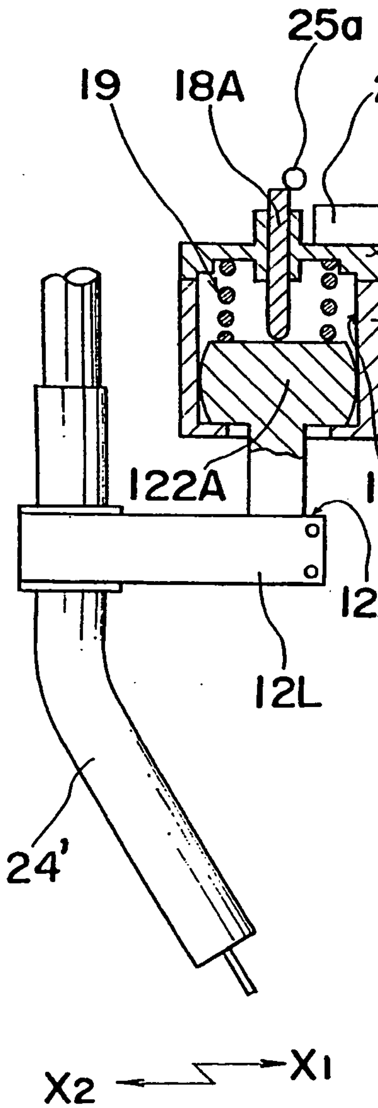

25a
11A
19
18A
25
14A
17
13A
122A
132A
12A
12L
24'
Z1
Z2
X2
X1

Fig. 12

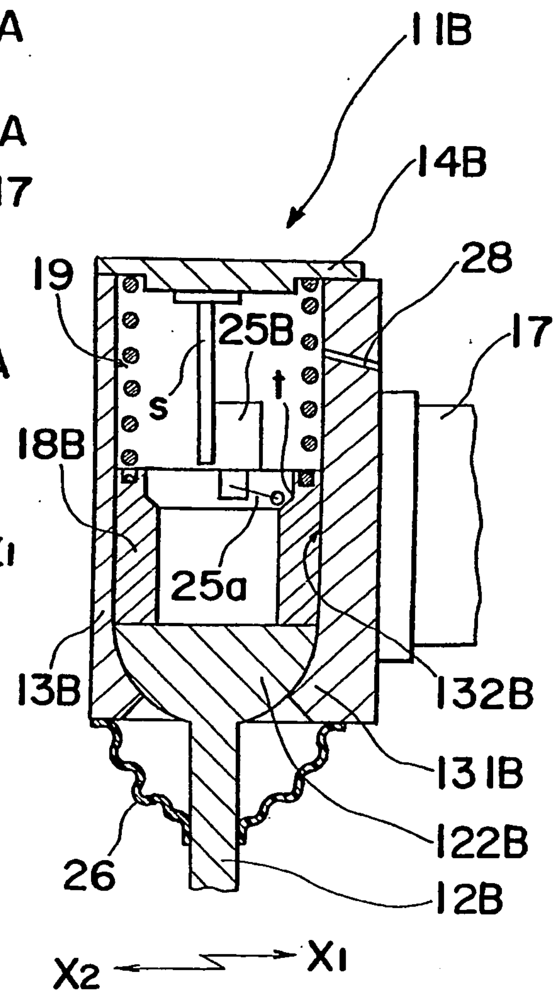

11B
14B
19
28
25B
17
s
t
18B
25a
13B
132B
131B
122B
26
12B
X2
X1

Fig. 13

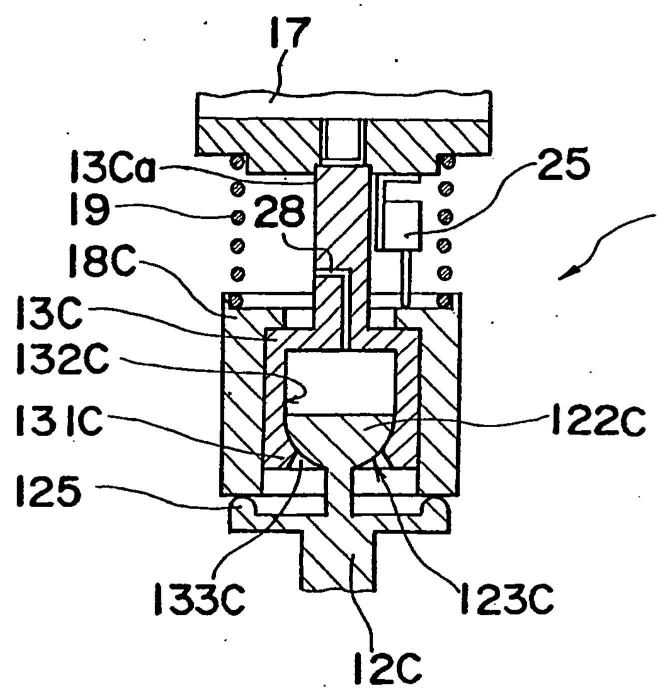


Fig. 15

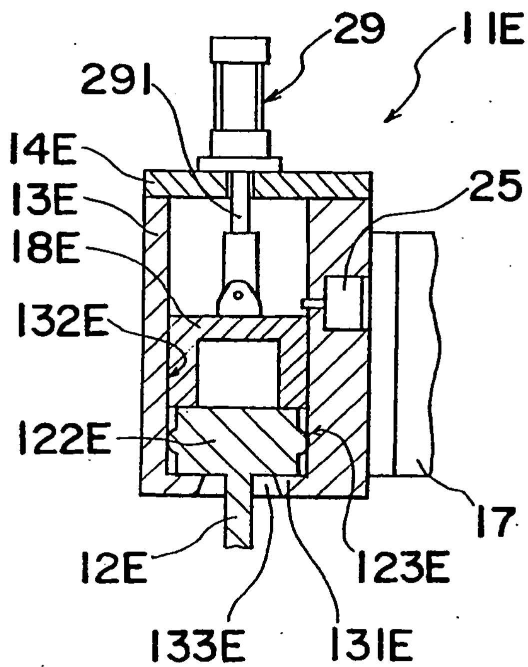
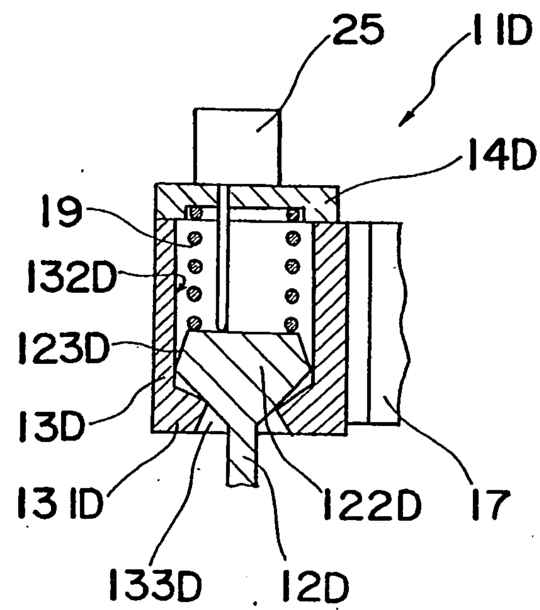


Fig. 14



SPECIFICATION

Industrial robot

The present invention generally relates to an industrial handling equipment and more particularly, to an industrial robot or working robot for use in a production line, an assembly line etc., which is capable of properly controlling positions of a movable unit thereof for supporting an operating element, for example, a welding torch or the like.

Generally, in industrial robots as referred to above, it has been a common practice to operate the robot by causing a microcomputer to function based on numerical data or input data through teaching procedures or by actuating a fixed electrical sequence control device.

In the known arrangements as described above, however, if any obstacle should be located in a functioning area of the robot by accident, for example, the operating element is brought into contact with the obstacle, thus resulting in damages to the operating element or the movable unit which supports said operating element. Accordingly, it has been required to provide a robot having a safety device for preventing damages to various parts and components. Moreover, in the industrial robot as described above, external force acting on the operating element is scarcely limited in one direction, and, therefore, in order to protect the operating member, etc. against damages, even when external forces in unspecified directions are applied thereto, it is necessary to allow the operating element to escape in the acting directions of such external forces.

For the industrial robot of the above described kind, there has conventionally been proposed a robot provided with a safety device having a construction as shown in Figs. 1 and 2, which is so arranged that, by providing a spherical bearing 53 including a spherical concave member 51 and a spherical convex member 52 in an opening formed at a forward end (i.e. at a lower end in Fig. 1) of a movable unit P11 properly controllable for positions, an operating element, for example, a welding torch P24 is disposed to extend through a through-hole 54 of the spherical convex member 52, while the welding torch P24 is urged by a spring 55 in a direction indicated by an arrow Z2 so as to allow the welding torch P24 to be tilted or to be moved in a direction indicated by an arrow Z1. Moreover, an arcuate fixed electrode 57 is mounted in another opening at a upper end (i.e. in Fig. 1) of the movable unit P11 through an insulating member 56, while, at a upper end of the welding torch P24 where said fixed electrode 57 is located, there are mounted first movable electrodes 58 arranged in a radial configuration and second movable electrodes 59 radially outwardly extending therefrom, with the state of displacement of the welding torch P24 being detected through the first and second movable electrodes 58 and 59 and the fixed electrode 57 by a detector 60 connected thereto.

More specifically, in the above known arrangement, in the case where, for example, a force is applied to the lower end of the welding torch P24 in an X directions or Y directions, said welding torch P24 is rotated about the spherical bearing 53 for contact of said first movable electrode 58 with the fixed electrode 57. Meanwhile, in the case where a force in the Z1 direction is applied to the lower end portion of the welding torch P24, the welding torch P24 extending through the through-hole 54 of the spherical convex member 52 is moved in the Z1 direction against the spring 55 to bring the second movable electrode 59 into contact with the fixed electrode 57. Although the welding torch P24 is displaced in the acting direction of the external force as described above, the amount of displacement of the welding torch P24 with respect to the moving member P11 is limited to an extremely small value, since the state of displacement of the welding torch P24 is arranged to be detected by the contact of the movable electrodes 58 and 59 and the fixed electrode 57. In other words, as the amount of displacement of the welding torch P24 becomes large, the movable electrodes 58 and 59 are depressed against the fixed electrode 57 more than necessarily or the upper end of the welding torch P24 is brought into contact with the movable unit P11, thus resulting in breakage of the movable electrodes 58 and 59 and welding torch P24. Moreover, for smoothly tilting the spherical convex member 52 at the spherical bearing portion 53, the spherical convex member 52 and the spherical concave member 51 must be respectively processed at high accuracy, and furthermore, for holding the spherical convex member 52 by the spherical concave member 51, it is necessary to divide the spherical concave member 51 at least into two portions in a radial or axial direction, and therefore, the processing of inner faces of the divided spherical concave member 51 into a smooth spherical configuration also requires a troublesome procedure. Additionally, there has been such a disadvantage that, if the through-hole 54 of the spherical convex member 52 is enlarged for a smooth movement of the welding torch P24, the positioning of the operating element, i.e. the welding torch P24 in this case becomes inaccurate.

Accordingly, an object of the present invention is to provide an industrial robot in which an operating member is supported so as to be free from positional deviations during operations of the robot and capable of being tilted and slidably moved with respect to a moving unit thereof. In this way the operating element is freely displaced in the acting directions of external forces, without a possibility of damages to various parts and components, while any abnormal state in the above case may be detected by a single detector, irrespective of acting directions of external forces, with the moving unit and the operating element being positioned to each other at a high accuracy by urging means for effecting operations required as a robot in an efficient manner, in spite of the fact that said moving unit and operating element are arranged to be tiltable and movable with respect to each other.

Another important object of the present invention is to provide an industrial robot of the above described type which is simple in construction, and can be readily manufactured at low cost for applica-

tions to various fields in industries.

In accomplishing these and other objects, according to an preferred embodiment of the present invention, there is provided an industrial robot which includes a fixed base, a rotary frame rotatably mounted on said fixed base for rotation in a horizontal direction with respect to said fixed base, an upper arm pivotally connected with the rotary frame, through a link means, for upward and downward pivotal movements thereof about pivotal connection by drive means, and a movable unit provided at one end of said upper arm and including a first movable member for supporting an operating element and a second movable member for supporting said first movable member so as to be controlled in positions thereof as required. The second movable member is formed into a cylindrical portion having a bottom portion, with a through-opening being formed in the bottom portion so as to axially extend through said bottom portion while the first movable member is directed, at its free end, into said cylindrical portion having said bottom portion, at least through said through-opening of said second movable member, with an expanded portion being formed on said free end of the first movable member so as to allow said first movable member to move in an axial direction of said second movable member and a direction inclined with respect to said axial direction.

The industrial robot further includes means for urging said expanded portion of said first movable member to contact said bottom portion of said second movable member, and a detecting means for producing alarm signal when said first movable member is displaced by more than a predetermined amount with respect to said second movable member against the urging force of said urging means.

By the arrangement according to the present invention as described above, an improved industrial robot free from any damages to various parts, and highly efficient in operations has been advantageously presented.

These and other objects and features of the present invention will become apparent from the following description, by way of example only, with reference to the accompanying drawings, in which;

Fig. 1 is a longitudinal sectional view of a safety device for a conventional industrial robot,

Fig. 2 is a cross section taken along the line II-II in Fig. 1,

Fig. 3 is a perspective view showing the construction of an industrial robot according to one preferred embodiment of the present invention,

Fig. 4 is a front elevational view, partly in section, showing on an enlarged scale, a moving unit which holds an operating element as employed in the arrangement of Fig. 3,

Fig. 5 is a side elevational view of the portion of Fig. 4,

Fig. 6 is a fragmentary sectional view showing, on a still enlarged scale, a main portion of the arrangement of Fig. 4,

Fig. 7 is a view similar to Fig. 6, which particularly shows the state where an external force is applied to a first movable member thereof in a horizontal direction,

Fig. 8 is a view similar to Fig. 6, which particularly shows the state where an external force is applied to a first movable member thereof in a vertically upward direction,

Figs. 9 and 10 are views similar to Fig. 4, which particularly show the state of functionings thereof equivalent to Figs. 7 and 8, and

Figs. 11 to 15 are views similar to Figs. 4 and 6, which particularly show modifications thereof.

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Referring now to the drawings, there is shown in Fig. 3, a multi-joint arm type industrial robot R according to one preferred embodiment of the present invention, which generally includes a rotary frame 1 rotatably mounted on a fixed base 2 for rotation in a horizontal direction with respect to the fixed base 2, a lower arm 3 and a link lever 4 each pivotally connected, at its one end, to said rotary frame 1, a rear arm 5 pivotally connected, at its one end, to the other end of the link lever 4, and an upper arm 6 pivotally connected, at its rear end portion 6b, to the corresponding other ends of the lower arm 3 and the rear arm 5 so as to constitute a parallel link mechanism by said upper arm 6, lower arm 3, link lever 4 and rear arm 5, while, at a forward end 6a of the upper arm 6, a movable unit 11 is directly supported or indirectly supported through a proper driving mechanism, for example, a horizontal rotary mechanism 10. The industrial robot R of Fig. 3 further includes a first and a second rotational driving means, for example, electric motors 7 and 8 supported by the rotary frame 1, and the lower arm 3 is arranged to be rotated for a vertical movement by the first motor 7 through a reduction gear (not shown), while the upper arm 6 is rotated about the pivotal connection thereof with respect to the lower arm 3 for upward and downward movements through the link lever 4 driven by the second motor 8 through a reduction gear (not shown) and the rear arm 5. On the other hand, the rotary frame 1 is rotated in the horizontal direction through another reduction gear (not shown) by third rotational driving means, for example, an electric motor 9 accommodated in the rotary frame 1.

In the embodiment in Fig. 3, the movable unit 11 is supported at the forward end 6a of the upper arm 6 through the horizontal rotating mechanism 10, with a suitable operating element, for example, a welding torch 24 of a consumable electrode type being supported by the movable unit 11. More specifically, in Figs. 4 and 5, the movable unit 11 further includes a first movable member 12 supporting, at its lower end, the operating element, i.e. the welding torch 24, which is, in this case, threaded onto the first movable member 12. The first movable member 12 has a through-hole 121 generally axially formed therein, and the end portion of the first movable member 12 in the Z1 direction is formed into a disc-like expanded portion 122 radially outwardly extending therefrom, while an outer peripheral surface of the expanded portion 122 is formed into a

convex portion 123 having a spherical configuration (Fig. 6). For supporting the first movable member 12 as described above, there is further provided a second movable member 13 which includes a bottom portion 131 and a cylindrical portion 132 connected to or integral with said bottom portion 131. The bottom portion 131 of the second movable member 13 is formed with a through-hole 133, through which the expanded portion 122 of the first movable member 12 is accommodated in the cylindrical portion 132 of the second movable member 13, with a flange-like under surface 124 of the expanded portion 122 contacting the bottom portion 131 of the second movable member 13 (Fig. 6). It should be noted here that, since the curvature of the spherical convex portion 123 of the expanded portion 122 is formed to have a radius generally equal to that of the cylindrical portion 132, the first movable member 12 may be tilted or slid as desired with respect to the second movable member 13. Within the cylindrical portion 132 of the second movable member 13 in a position between the second movable member 12 and a spring presser 14 fitted into an upper end of the cylindrical portion 132, there is disposed a compression spring 19, by which the first movable member 12 is normally urged in the Z2 direction. A cap member 15 applied over the spring presser 14 is connected onto the second movable member 13 together with the spring presser 14 as one unit so as to be supported by a bracket 17 through a suitable electrical insulating member 16 for connection with a horizontal rotating mechanism 10, and thus, the movable unit 11 is constituted by the members 12 to 17 as described so far.

The arrangement of Figs. 3 and 4 further includes a sleeve 18 disposed to extend through an axial bore of the spring presser 14 for movement in the Z directions, and formed into a cylindrical configuration having a flange portion 181 provided at its end in the Z1 direction. Between the cap member 15 and the sleeve 18, there is disposed a compression spring 20, by the spring force of which, the sleeve 18 is normally urged in the Z2 direction so as to contact the first movable member 12. A flexible guide 21 provided between the cap member 15 and the welding torch 24 is made, for example, of a wire material having a circular or non-circular cross section and formed into a spiral configuration or of a tube of synthetic material. Although not particularly shown, in the embodiment of Fig. 4, a lower end portion of a flexible conduit tube for guiding a consumable electrode wire is threaded onto a threaded portion 151 provided on the cap member 15. Meanwhile, a connecting port 22 is provided in the side wall of the second movable member 13 for supplying shielding gas for welding therethrough, and a space communicated with said connecting port 22 is shielded through a proper air tight members 231, 232, 233 and 234, and is further communicated with the welding torch 24 through an opening 182 formed at the lower portion of the sleeve 18 in the Z2 direction. At the upper portion of the spring presser 14, there is provided a detector 25 so disposed, for example, as to detect the position of the flange portion 181 of the sleeve 18. The lower portion of the first movable member 12 threaded onto the welding torch 24 is surrounded by a flexible cover 26 made, for example, of rubber or synthetic resin and the like. A power cable 27 for welding is connected to the welding torch 24 after being supported, for example, by the cap member 15.

By the above arrangement, for example, welding of an object to be welded, i.e. a workpiece is effected through proper control of positions of the movable unit 11. In this case, since the expanded portion 122 of the first movable member 12 urged by the spring 19 is brought into contact with the bottom portion 131 of the second movable member 13, the shielding gas supplied through the connecting port 22 reaches the welding torch 24 through the lower portion of the sleeve 18. Meanwhile, the consumable electrode wire (not particularly shown) is fed to the welding position, while being guided by the flexible guide 21, and the welding is effected by feeding electric power to the welding torch 24 through the power cable 27.

Referring particularly to Figs. 6 through 8, functionings of the industrial robot according to the present invention, and, more particularly, functionings of the movable unit thereof will be described hereinbelow with reference to a case where an external force is applied to the lower end of the welding torch 24 while the industrial robot is in operation, i.e. during the welding or non-welding period.

In Fig. 6 showing the state where no external force is applied to the welding torch 24, it is assumed, for example, that an external force is applied to the lower end of the welding torch 24 in the X1 direction. In this case, since the curvature of the spherical convex portion 123 of the expanded portion 122 for the first movable member 12 is formed to have the radius generally equal to that of the cylindrical portion 132 of the second movable member 13 as described earlier, said first movable member 12 tends to be tilted or turned in the counterclockwise direction, and in the above state, owing to the arrangement that the first movable member 12 is urged in the Z2 direction by the spring 19, with the flange-like under surface 124 of the expanded portion 122 contacting the bottom portion 131 of the second movable member 13, the first movable member 12 is properly tilted at a position O2 where the center of sphere O1 for the expanded portion 122 has been displaced by a distance dZ1 in the Z1 direction, in which case, the sleeve 18 is shifted by a distance dZ2 in the Z1 direction as shown in Fig. 7. On the other hand, in the case where an external force in the Z1 direction is applied to the lower portion of the welding torch 24, the expanded portion 122 of the first movable member 12 is displaced, for example, by a distance dZ3 in the Z1 direction along the cylindrical portion 132 (Fig. 8).

It is to be noted here that, since the expanded portion 122 of the first movable member 12 is formed into the spherical convex configuration, the first movable member 12 may be tilted in any direction with respect to the second movable member 13, and moreover, since the expanded portion 122 is formed into a disc-like configuration, with the contacting surface of the sleeve 18 normally contact-

ing the disk-like expanded portion 122 being formed into a cylindrical shape, the sleeve 18 is moved in the Z1 direction irrespective of the direction of tilting of the first movable member 12. More specifically, on the assumption that the first movable member 12 is tilted to displace the spherical center point O1 in the Z1 direction by the distance dZ1, the sleeve 18 is shifted in the Z1 direction by the distance dZ2 regardless of the direction of tilting.

As described so far, upon application of external forces to the lower end of the welding torch 24, the sleeve 18 is moved in the predetermined direction, i.e. in the Z1 direction irrespective of the directions of application of the external forces, and therefore, by properly selecting the state of output of the detector 25 for detecting the positions of the sleeve 18, it is possible to detect the abnormal state of the welding torch in any direction by the single detector.

Furthermore, in the arrangement according to the present invention as described in the foregoing, since the play between the first movable member 12 and the through-opening 133 of the second movable member 13, and also the play between the sleeve 18 and the first movable member 12 in the Z directions, may be properly selected, the welding torch 24 and the first movable member 12, etc. are freely displaced in the acting directions of external forces with respect to other members, without any possibility of damages to various parts.

Reference is further made to Figs. 9 and 10 showing the state of functionings of the arrangement of Fig. 4 and equivalent to Figs. 7 and 8 as described above.

As shown in Fig. 9, even when the welding torch 24 or the like supported by the movable unit 11 is displaced by an external force, the consumable electrode wire (not particularly shown) guided by the flexible guide 21 does not contact other members, and therefore, upon removal of the external force acting on the operating element such as the welding torch 24 or the like, said operating element may be automatically restored back to the initial state as shown in Fig. 4. It is needless to say that, upon detection of the abnormal state of the welding torch 24, the welding operations or other work related thereto may be suspended by an abnormal signal, or warnings for such abnormal state may be given.

Referring further to Figs. 11 to 15, there are shown modifications of the arrangement described so far with reference to Figs. 3 to 10, and more particularly, modifications thereof related to the portions associated with the movable unit 11.

In the modified movable unit 11A of Fig. 11, the first movable member 12 of Fig. 4 is replaced by a first movable member 12A which supports an operating element or a slightly curved welding torch 24', through a bracket 12L extending outwardly from the lower end of the movable member 12A in a direction at right angles thereto, so that the axis of the first movable member 12 is not aligned with that of the operating member 24' as shown. On the other hand, the sleeve 18 in Fig. 4 is also modified into a sleeve 18A of a rod-like shape axially extending through the cap member 14A, and contacting, at its lower end, the upper face of the expanded portion 122A of the first movable member 12A within the second movable member 13A and, at its upper end, a detection arm 25a of the detector 25 mounted on the cap member 14A in a position adjacent to said sleeve 18A.

Meanwhile, in the modified movable unit 11B of Fig. 12, the first movable member 12 of Fig. 4 is replaced by a first movable member 12B having the expanded portion 122B formed into a hemi-spherical convex portion. Moreover, the second movable member 13 in Fig. 4 is modified into a second movable member 13B having the bottom portion 131B formed into a hemi-spherical concave portion integral with the cylindrical portion 132B. The sleeve 18B arranged to be moved in the Z directions within the cylindrical portion 132B of the second movable member 13B is formed into a cylindrical shape having a taper portion t provided in an inner periphery at the upper end of said sleeve 18B, while a detection arm 25a of the detector, for example, a microswitch 25B supported by the cap member 14B through a suitable support S is arranged to contact said taper portion t. By the above construction, the positional detection of the sleeve 18B is not adversely affected at all, even if the position of the sleeve 18B in the cylindrical portion 132B is deviated in the rotational direction. Nevertheless, it may further be so modified that, for example, by providing a groove (not shown) in the cylindrical portion 132B in the axial direction, with a projection (not shown) engageable with said groove 18B being formed on the sleeve 18B, the sleeve 18B is restricted with respect to the rotating direction, although movable in the axial direction of the cylindrical portion 132B. In the arrangement of Fig. 12, an air vent 28 if formed in the wall of the cylindrical portion 132B of the second movable member 13B for smooth movements of the first movable member 12B and the sleeve 18B.

On the other hand, in another modified movable unit 11C in Fig. 13, although the modified first movable member 12C has the expanded portion 122C similar to the expanded portion 122B in Fig. 12, and the modified second movable member 13C has the bottom portion 131C and cylindrical portion 132C generally similar to those in the arrangement of Fig. 12, said first movable member 12C is further formed with an annular protrusion 125 having a diameter larger than that of the second movable member 13C, with said protrusion 125 contacting the corresponding low edge of the modified sleeve 18C of a cylindrical shape arranged to be guided by the second movable member 13C for movement in the axial direction. Meanwhile, the second movable member 13C is provided with a reduced diameter portion 13Ca extending upwardly therefrom up to the support bracket 17 and formed therein with the air vent 28, with the compression spring 19 being disposed between the sleeve 18C and the bracket 17 so as to surround said reduced diameter portion 13Ca, while the contact arm of the detector 25 is arranged to contact the upper portion of the sleeve 18C.

In the modified movable unit 11D in Fig. 14, the expanded portion 122D of the first movable member 12D is formed with the outer peripheral convex

portion 123D which has an outer diameter slightly smaller than the inner diameter of the cylindrical portion 132D of the second movable member 13D, and the detection arm of the detector 25 mounted on the cap member 14D applied onto the second movable member 13D is arranged to contact the upper surface of the expanded portion 122D through said cap member 14D.

On the other hand, in the further modified movable unit 11E in Fig. 15, the expanded portion 122E of the first movable member 12E is formed with the outer peripheral convex portion 123E in a flange-like configuration, which also has an outer diameter somewhat smaller than the inner diameter of the cylindrical portion 132E of the second movable member 13E. The modified sleeve 18E movably accommodated in the cylindrical portion 132E of the second member 13E on the upper surface of the expanded portion 122E of the first movable member 12E, is connected, at its upper portion, to the end portion of a rod 291 of a cylinder 29 operated by a pressure fluid and disposed on the cap member 14E applied onto the second member 13E so as to be normally urged in the Z2 direction. In the above case, if a gas such as a compressed air, compression gas or the like is employed for the pressure fluid, it becomes possible to effect a fine adjustment of pressure in a comparatively small degree, and in the case where an impact force is applied to the hydraulic operating cylinder 29, the shock may be advantageously absorbed by the pressure gas portion.

As is seen from the foregoing description, if the detector 25 is disposed as shown in Figs. 4, 12 and 15, there is no possibility that such detector is damaged by the contact thereof with other members. Meanwhile, as shown in Figs. 4 and 12, if the movable portion of the first movable member and the sleeve are accommodated in the cylindrical portion of the second movable member, the arrangement is free from entry of dust and dirts or the like, and thus, smooth movements of the first movable member and the sleeve may be maintained. Moreover, by forming the expanded portions for the first movable members as shown in Figs. 4, 11, 12 and 13, the tilting and sliding movements of the operating element, e.g. welding torch or the like, and of the first movable members may be effected smoothly. Furthermore, as shown in Figs. 4, 11, 14 and 15, when the expanded portion is formed on the first movable member, with the bottom portion of the second movable member being formed into a flat surface, manufacturing and assembly thereof may be facilitated. On the other hand, if the annular protrusion 125 of a large diameter is provided on the first movable member as shown in Fig. 13, even a state of a minor tilting may be detected, since the displacement of the sleeve to be moved during tilting of the first movable member is enlarged. In the case where the detector 25 is provided so as to be operable from the outer side as shown in Figs. 11 and 13, it becomes possible to effect a minor adjustment of the detecting state. Moreover, although the inexpensive spring member may be employed for the urging means as described earlier, it is possible to employ the hydraulic means as in Fig. 15 or an electro-magnet and the like (not shown) for the urging means. It is to be noted here that, if the operating element and the first movable member have large weights, such weights may be utilized as an urging means. When the axes of the operating element, for example, the welding torch and the expanded portion of the first movable member are arranged to be generally aligned with each other, the arrangement may be suitably applied to industrial robots for welding purposes, etc., since protrusion of each portion in the radial direction is comparatively small. Furthermore, as shown in Fig. 11, it is possible to arrange such that the axis of the operating element, for example, the welding torch is not in agreement with the axis of the expanded portion of the first movable member, in which case, the height from the free end of the operating element up to the movable member may be advantageously reduced.

In the embodiments of the present invention as described so far, a differential transformer, optical sensor, magnetic sensor or the like of a suitable contact or non-contact type may be utilized for the detector. Meanwhile, for the operating element, any other suitable tools such as a painting spray gun, assembly tool, gripping tool or the like may be properly selected besides the welding torch. It should also be noted that, the present invention may also be applied to suitable industrial robots, for example, of a cylindrical coordinate type or rectangular coordinate type as well.

As is clear from the foregoing description, according to the arrangement of the present invention, since the operating element is supported so as to be free from any positional deviation during operation of the industrial robot, it is possible to effect desired operations positively, while owing to the fact that the operating element is arranged to be tiltable and slidable with respect to the movable member, the operating element can be freely displaced in the acting direction of the external force upon application of an external force to the operating element by an unexpected cause, and therefore, there is no possibility that various parts are damaged. Furthermore, in the above case, unusual state may be detected by the single detector, while, owing to the arrangement that the movable member and the operating element are mutually positioned by the urging means at high accuracy, in spite of the fact that they are adapted to be tiltable and slidable with respect to each other, desired operations as the industrial robot may be effected positively in an efficient manner.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as included therein.

CLAIMS

1. An industrial robot comprising a movable unit including a first movable member for supporting an operating element and a second movable member

for supporting said first movable member, and means for controlling positions of said movable unit as required, said second movable member being formed into a cylindrical portion having a bottom portion, with a through-opening being formed in the bottom portion so as to axially extend through said bottom portion, said first movable member being directed, at its free end, into said cylindrical portion having said bottom portion, at least through said through-opening of said second movable member, with an expanded portion being formed on said free end of the first movable member so as to allow said first movable member to move in an axial direction of said second movable member and a direction inclined with respect to said axial direction, means for urging said expanded portion of said first movable member to contact said bottom portion of said second movable member, and a detecting means for producing alarm signal when said first movable member is displaced by more than a predetermined amount with respect to said second movable member against the urging force of said urging means.

2. An industrial robot according to Claim 1, wherein said means for controlling positions of said movable unit includes a fixed base, a rotary frame rotatably mounted on said fixed base for rotation in a horizontal direction with respect to said fixed base, and an upper arm pivotally connected with said rotary frame, through a link means, for upward and downward pivotal movements about the pivotal connection by drive means, said movable unit being provided at one end of said upper arm.

3. An industrial robot according to Claims 1 and 2, wherein said bottom portion of said second movable member is formed into a flat surface, and wherein said expand portion of said first movable member includes a flat surface contacting said bottom portion and a head portion contacting an inner wall of the cylindrical portion of said second movable member.

4. An industrial robot according to Claim 3, wherein said head portion of the expanded portion of said first movable member is formed into a spherical configuration contacting the inner wall of the cylindrical portion of said second movable member.

5. An industrial robot according to Claims 1 and 2, wherein said bottom portion of said second movable member is formed into a hemi-spherical concave portion connecting to said cylindrical portion, and wherein said expanded portion of said first movable member is formed into a corresponding hemi-spherical convex portion contacting said bottom portion of said second movable member.

6. An industrial robot according to any one of Claims 1 to 5, wherein said urging means is at least weights of said operating element and said first movable member.

7. An industrial robot according to any one of Claims 1 to 5, wherein said urging means is constituted by a spring member.

8. An industrial robot according to any one of Claims 1 to 5, wherein said urging means is constituted by a pressure fluid operating cylinder.

9. An industrial robot according to Claim 8, wherein said pressure fluid operating cylinder is of a pressure gas operating cylinder.

10. An industrial robot according to any one of Claims 1 to 5, wherein said urging means is constituted by an electro-magnet.

11. An industrial robot comprising a movable unit including a first movable member for supporting an operating element and a second movable member for supporting said first movable member, and means for controlling positions of said movable unit as required, said second movable member being formed into a cylindrical portion having a bottom portion, with a through-opening being formed in the bottom portion so as to axially extend through said bottom portion, said first movable member being directed, at its free end, into said cylindrical portion having said bottom portion, at least through said through-opening of said second movable member, with an expanded portion being formed on said free end of the first movable member so as to allow said first movable member to move in an axial direction of said second movable member and a direction inclined with respect to said axial direction, a sleeve member contacting said free end of said first movable member and movable in an axial direction of the cylindrical portion of said second movable member, means for urging said expanded portion of said first movable member to contact said bottom portion of said second movable member, and a detecting means for producing alarm signal when said first movable member is displaced by more than a predetermined amount with respect to said second movable member against the urging force of said urging means, by detecting position of said sleeve member.

12. An industrial robot according to Claim 11, wherein said means for controlling positions of said movable unit includes a fixed base, a rotary frame rotatably mounted on said fixed base for rotation in a horizontal direction with respect to said fixed base, and an upper arm pivotally connected with said rotary frame, through a link means, for upward and downward pivotal movements about the pivotal connection by drive means, said movable unit being provided at one end of said upper arm.

13. An industrial robot according to Claims 11 and 12, wherein said bottom portion of said second movable member is formed into a flat surface, and wherein said expanded portion of said first movable member includes a flat surface contacting said bottom portion and a head portion contacting an inner wall of the cylindrical portion of said second movable member.

14. An industrial robot according to Claim 13, wherein said head portion of the expanded portion of said first movable member is formed into a spherical configuration contacting the inner wall of the cylindrical portion of said second movable member.

15. An industrial robot according to Claims 11 and 12, wherein said bottom portion of said second movable member is formed into a hemi-spherical concave portion connecting to said cylindrical portion, and wherein said expanded portion of said first

movable member is formed into a corresponding hemi-spherical convex portion contacting said bottom portion of said second movable member.

16. An industrial robot according to any one of Claims 11 to 15, wherein said urging means is at least weights of said operating element and said first movable member.

17. An industrial robot according to any one of Claims 11 to 15, wherein said urging means is constituted by a spring member.

18. An industrial robot according to any one of Claims 11 to 15, wherein said urging means is constituted by a pressure fluid operating cylinder.

19. An industrial robot according to Claim 18, wherein said pressure fluid operating cylinder is of a pressure gas operating cylinder.

20. An industrial robot according to any one of Claims 11 to 15, wherein said urging means is constituted by an electro-magnet.

21. An industrial robot according to any one of Claims 11 to 20, wherein said sleeve member is disposed generally in a coaxial relation with respect to said cylindrical portion of said second movable member.

22. An industrial robot according to Claim 21, wherein said sleeve member is formed into a cylindrical configuration.

23. An industrial robot substantially as hereinbefore described with reference to figures 3 to 15.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1983.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.